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Palm oil: Addressing issues and towards sustainable development

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Abstract

The quest for renewable energy has intensified since the escalating price of crude petroleum in the recent years. Renewable energy such as biodiesel has the potential to replace petroleum-derived transportation fuel in the future. Biodiesel is defined as the mono-alkyl esters of long-chain fatty acids derived from vegetable oils such palm oil, rapeseed and soybean. Currently, more than 80% of the world biodiesel productions are from rapeseed oil. However, the cost of palm oil which is at least US$ 200 per tonne cheaper than rapeseed oil indicates that palm oil could be a more suitable and attractive candidate as the source of biodiesel compared to other vegetable oils. Although palm oil is known to be a multi-purpose vegetable oil with products ranging from food to biodiesel, there are a lot of issues surrounding palm oil production. Nevertheless, some of these issues reported in the literature were found to be misleading and are thus confusing the public perception on palm oil. Thus, the aim of this paper is to highlight and clarify the negative issues reported in the literature surrounding palm oil production. Apart from that, various policies or/and strategies that will lead to a more sustainable production and development of palm oil industries will also be proposed. Hence, palm oil will be able to become the leading vegetable oil in terms of food and non-food production, especially as the main source of renewable energy, biodiesel.

Keywords: Biodiesel; Palm oil; Renewable energy; Sustainable production

Contents

1. Introduction

Fossil fuels such as petroleum, natural gas and coal have been the main source of power supply around the world. Most countries depend on fossil fuels to generate energy including electricity which is essential for continuous development and economic growth. However, the world reserve for fossil fuels such as petroleum has been depleting and causing the price to hit above US$ 60 per barrel as of May 2007 [1]. Consequently, the search for alternative energy which is renewable and environment-friendly has been carried out worldwide. Renewable energy will not pollute the environment like fossil fuels

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Table 1
Percentage of biodiesel produced worldwide from various vegetable oils [3]

Source of biodiesel	Percentage (%)
Rapeseed oil	84
Sunflower oil	13
Palm oil	1
Soybean oil and others	2

that emit carbon monoxide, carbon dioxide, SO_x, NO_x and particulates when combusted and subsequently cause green house effect, acid rain, human health and environmental deterioration.

One of the extensively researched renewable energy around the world is biodiesel. Biodiesel is defined as the mono-alkyl esters of long-chain fatty acids derived from renewable feedstock, such as vegetable oils. It is synthesized from the triglycerides in vegetable oils by transesterification reaction with alcohol. In this reaction, the oil reacts with an alcohol in a number of consecutive, reversible steps to form esters and glycerol [2].

Currently, the vegetable oils that are used in the industries to produce biodiesel are palm oil, soybean, rapeseed and sunflower as shown in Table 1. From the table, it can be seen that majority of biodiesel produced worldwide is from rapeseed oil, which covers 84% of total production. Even though the current production of biodiesel from palm oil is insignificant, with only 1% from total world production, it remains the most attractive candidate due to the high yield of oil palm tree as shown in Fig. 1. From the figure, it is obvious that the average yield of palm oil is approximately 4.2 tonnes per hectare per year, far exceed other vegetable oils. For instance, two other major oils like rapeseed and soybean produce only 1.2 and 0.4 tonnes per hectare per year, respectively. Apart from that, the production cost of palm oil is relatively cheaper compared to other vegetable oils. Subsequently, it is not surprising to note that palm oil remains the cheapest and competitive vegetable oil traded in the market as shown in Fig. 2. Since 2005, total production of palm oil in the world has matched the production of soybean oil, which is currently the largest source of vegetable oil produced in the world. However, when comparing the trading trend of these two crops in the market, global export of palm oil exceeds soybean oil's value by nearly triple as shown in Fig. 3 [3]. This low traded soybean oil indicates that most of the oil produced are sufficient to meet only the local demand of oil. Insufficient supply of soybean oil therefore hinders the utilization of this oil as an ideal source of biodiesel although it is the largest source of vegetable oil produced. Hence, with increasing production and trading activities of palm oil in the global market, this makes palm oil an attractive and ideal candidate for biodiesel production.

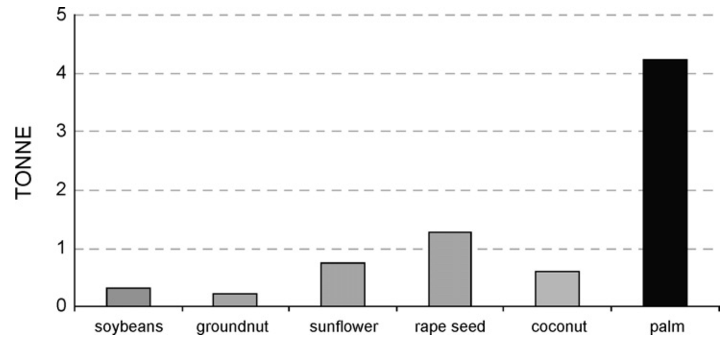


Fig. 1. Yield of selected vegetable oils (oil per hectare per year, 2004–2006 average) [3].

Currently, European Union (EU) countries are the largest producer and consumer of biodiesel synthesized from rapeseed oil. However, this low yield and high priced crop is also not an ideal source of biodiesel as the demand for biodiesel will grow and subsequently exceed the supply capacity. Instead, palm oil, a high-yield crop with the lowest price trade among the vegetable oils has the potential as the main source of biodiesel.

Palm oil (*Elaeis guineensis*) is believed to be indigenous to West Africa (the specific name, *guineensis* shows that the first specimen described was collected in Guinea, West Africa). There is a general consensus that commercially planted palms in Indonesia, Malaysia and other South East Asia locations were derived from West African [4]. In 2005, Malaysia and Indonesia produced nearly 80% of 35 million tonnes total world production of palm oil [5]. As the petroleum price keeps on

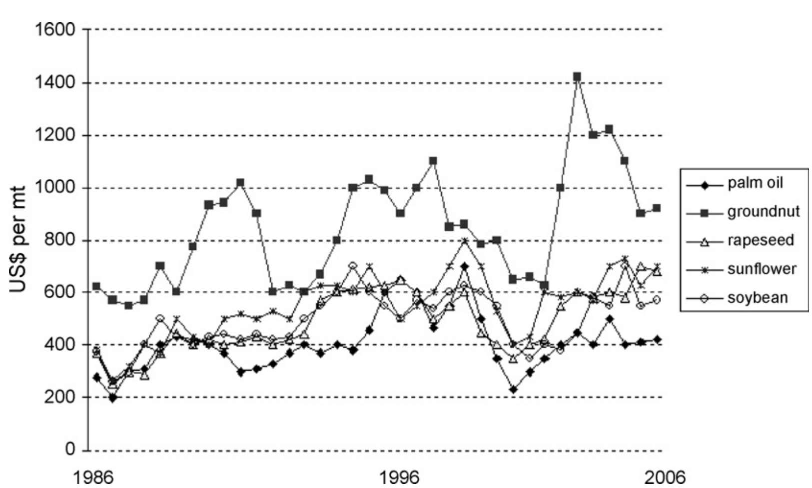


Fig. 2. World prices for selected vegetable oils [3].

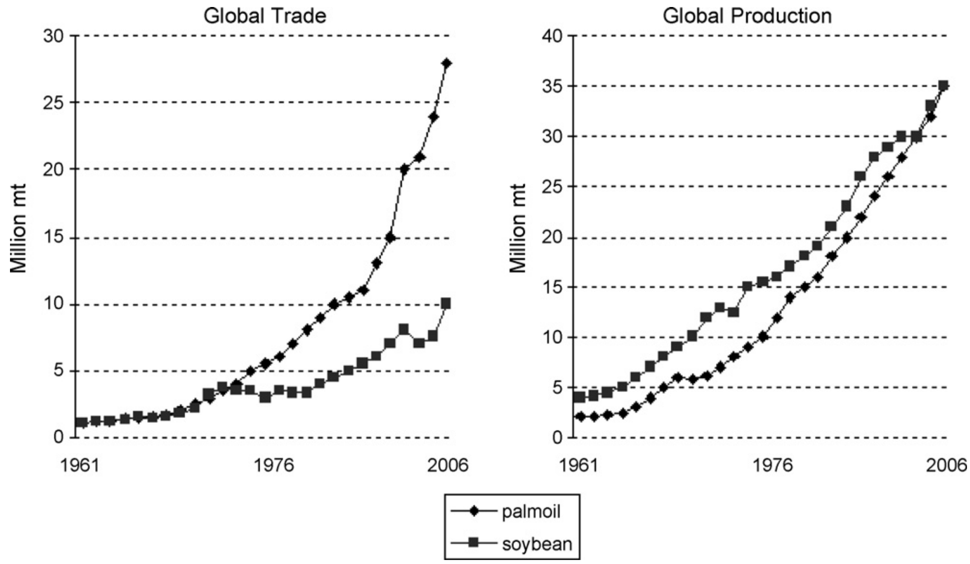


Fig. 3. Global production and trade for palm oil and soybean oil [3].

increasing while the worldwide production of palm oil is getting higher, it has created an attractive opportunity for palm oil to be used as the source of biodiesel to replace fossil fuels.

Apart from biofuel, palm oil also can be used for other purposes ranging from food products to cosmetics and also engine lubricants. These vast applications have made palm oil an increasingly important agricultural product for tropical countries around the world, especially as crude oil prices is getting higher than ever. For example, in Indonesia, currently the world's second largest producer of palm oil, oil palm plantations covered 5.3 million hectares of the country in 2004. These plantations generated 11.4 million metric tons of crude palm oil with an export value of US$ 4.43 billion. So, it is not surprising to note that millions of hectares across Malaysia, Indonesia, and Thailand are covered with palm oil plantations [6].

Despite the vast applications of palm oil, issues of palm oil cultivation are a concern and hotly debated around the world. For instance, there are a few environmental issues that arise such as deforestation, animal extinction and peatland destruction due to the expansion of oil palm plantation around the world. These issues need to be looked upon and solved before biodiesel from palm oil can become the main source of biofuel worldwide.

2. Issues

2.1. Deforestation

Deforestation is defined as the conversion of forested areas to other purposes such as agricultural, logging, urbanization, etc. Like any other crops, this issue is commonly associated when new opening of plantations took place. Palm oil is not exempted and it is claimed that virgin tropical forests are cleared to make way for oil palm plantations and causes a great effect to the ecology stability [7]. Besides, it was reported that planters prefer to clear virgin tropical forests to earn some income from the sale of timber instead of planting in cleared or abandoned land [8]. Consequently, tropical forests are being cleared for oil palm plantations and affected the natural habitats of tropical forests like tigers, Sumatran rhinoceros and Asian elephants.

A report by WWF shows that clearance of tropical forests for oil palm plantations has caused a lot of negatives effects [9]. The removal or destruction of significant areas of forest has resulted in ecology instability to the natural habitat of the forests. For instance, animal species like Asian elephants, Sumatran rhinos and Sumatran tigers, which can only be found in Sumatran and Borneo Island, are facing extinctions due to the high rate of tropical forests being converted to oil palm plantations. When their natural habitats are destroyed, these animals would not be able to survive and become endangered.

Glastra et al. [10] claims that most of the deforestation in South East Asia has been carried out using land burning where large scale clearance caused numerous, large and persistent fires in Sumatra. For example, it is claimed that the 1997 haze around South East Asia region is caused by this activity. Apart from that, it was also reported that from 5 million hectares of former forest in Indonesia, 3 million hectares are now covered with palm oil.

2.2. Orangutan extinction

Many sources also reported that the destruction of tropical forests in South East Asia for oil palm plantations caused many natural habitats to face extinctions. For instance, it was reported that Sumatran orangutans (*Pongo abelii*) and Bornean orangutans (*Pongo pygmaeus*), which are native in Sumatra and Borneo Island are facing extinction due to plantation expansion. Orangutans depend on tropical forests for food and nesting sites. When their natural habitats are degraded for agriculture purposes, they will have to migrate to less ideal place. Consequently, death rate increases and fewer births amongst females occur. Moreover, there are also reports that confused orangutans wandering in their former habitats that

have been turn into oil palm plantations are often killed for meat and to protect newly planted crops. With their habitat destroyed, hungry orangutans will turn their attention to the young palm trees, where they can cause considerable damage and thus creating conflict between human and orangutans. However, expansion of oil palm plantation is just one of the factors behind their extinction as other activities like illegal logging; forest fires, illegal hunting and trade also play a part [11].

2.3. Peatland destruction

Peatland is a type of land where the soil contains a high proportion of incomplete decomposed organic matter. This is caused by waterlogged conditions, where the lack of oxygen prevents microorganisms such as bacteria and fungi from rapidly decomposing the dead plants [12]. Globally, peatlands cover nearly 3% (some 4 million km^2) of the earth's land area and store a large fraction of carbon resources; up to 528,000 megatonnes, which is equivalent to one-third of global soil carbon and 70 times the current annual global emissions from fossil fuel burning [13]. Hence, peatlands play a very important role as carbon sink and to maintain a balance global total carbon cycle in the atmosphere. Besides, peatland soils are also important water retention areas, keeping water for months after the wet season and slowly releasing this during the dry season and consequently help to prevent floods and droughts.

Hooijer et al. [13] claims that South East Asia region is estimated to have 27.1 million hectares of peatlands or 6% of total peatlands in the world. Indonesia alone has 22.5 million hectares, which is 12% of its total land area. The peat swamp forests have remained relatively unharmed until recent years, as they were unattractive to agriculture. The infertile and wet soil is unsuitable for most crops. However, when deeply drained they are quite suitable for palm oil. The current increasing international demand for biofuel has accelerated the conversion activity of peatlands to palm oil plantations especially in Indonesia with nearly 25% of all oil palm plantations are on peatlands [14]. Consequently, massive emissions of the greenhouse gas carbon dioxide occur when the organic material are decompose due to contact with the air.

Peatland fire also contributed significantly to the CO_2 emissions in South East Asia and is believed to have emitted more than twice the amount from peatlands drainage. From 2 trillion tonnes of CO_2 emitted, 1.4 trillion tonnes is estimated due to peatlands fire while the rest from drainage activity. Peatland fires are not abnormal in Indonesia where it was claimed that more than 60,000 fires occurred since 1997 causing haze problem to the region itself. Moreover, the haze fires also cause respiratory diseases among children in Indonesia [14].

3. Palm oil industries: the real scenario

The accusation of deforestation and reduced biodiversity due to expansion of oil palm plantation is not in agreement with details reported by Malaysian Palm Oil Council (MPOC). Malaysia, the current leading producer and exporter of palm oil in the world, has 32 million hectares of total land. Out of this figure, only 19% or 5.4 million hectares are for various agricultural crops plantation. Despite producing a staggering 15 million tonnes of palm oil in 2005 [4], oil palm plantations in Malaysia only occupied a mere 4 million hectares or 10% of total land mass. On the other hand, by comparing the 'green cover' or total virgin forests and planted agricultural land, a stunning 76% of total land mass or more than 25 million hectares are available in Malaysia. On the contrary, forests in United Kingdoms (UK) occupy only 12% of total land mass, far less than Malaysia, which still has 64% of total land mass remained as rainforests. Apart from that, the agricultural land in UK makes up nearly 70% of total land available compared to less than 19% in Malaysia. If palm oil industries, particularly from Malaysia are accused of forest destruction, then the same accusation should be hurled at the agricultural activities in the UK [15]. However, currently, the focus of accusation of these NGOs is palm oil in South East Asian countries and not UK's agricultural activities.

Besides, environmentalist's claims that oil palm plantation expansion in Malaysia were carried out in virgin tropical forests are not acceptable. Even though Malaysia doubled its' oil palm plantation areas from nearly 2 million hectares in 1990 to 4 million hectares in 2005, this was carried out by replacing other agricultural crops like cocoa, rubber and coconut which have lower market values. As shown in Table 2, other agricultural crops have lost 1.141 million hectares which were mostly converted into oil palm plantations [15]. Hence, from 1990 to 2005, the net expansion of new land for oil palm plantation was less than 1 million hectares. This statistic is totally in contrast with some reports that claim the expansion was carried out massively in virgin tropical forests particularly in East Malaysia of Sabah and Sarawak.

On top of that, recent studies have shown that oil palm plantations may be more effective than rainforests in serving as 'carbon sink' which is an area of dry mass that absorb harmful greenhouse gases like carbon dioxide. On the contrary to NGOs claims that oil palm plantation is bad for carbon cycle in the atmosphere compared to virgin rainforests, it is reported that oil palm plantation assimilates up to 36.5 tonnes of dry matter per hectare per year while virgin rainforest only can assimilates 25.7 tonnes per hectare per year as shown in Table 3. Apart from that, the net assimilation of carbon dioxide is also higher for oil palm plantation compared to rainforest, which are 64.5 and 42.2 tonnes of CO_2 per hectare per year respectively. This shows that oil palm plantation is also able to function better

Table 2
Changes in land use of selected tree crops in Malaysia (million hectares) [15]

Crop	1990	2005
Oil palm	1.980	4.050
Rubber	1.823	1.250
Cocoa	0.416	0.033
Coconut	0.315	0.130
Total	4.534	5.463

Table 3
Physiological parameters of palm oil and tropical rainforest [16]

Parameter	Oil palm plantation	Rainforest
Gross assimilation (tonnes CO_2/hectare/year)	161.0	163.5
Total respiration (tonnes CO_2/hectare/year)	96.5	121.1
Net assimilation (tonnes CO_2/hectare/year)	64.5	42.4
Leaf area index	5.6	7.3
Photosynthetic efficiency (%)	3.2	1.7
Radiation conversion efficiency (g/m)	1.7	0.9
Standing biomass (tonnes/hectare)	100.0	431.0
Biomass increment/year (tonnes)	8.3	5.8
Dry matter productivity/year (tonnes)	36.5	25.7

than rainforest as far as carbon sequestration is concerned. The same study also shows that oil palm plantation accumulate 8.3 tonnes of biomass per year, higher than rainforest by 2.5 tonnes per year. This biomass is useful as it can act as a renewable source of ethanol and methane, which are valuable commodities in the market [16].

Besides, by considering the energy balance of major vegetable oils in the world, it is found that the energy ratio of output to input for palm oil is the highest compared to rapeseed or soybean. From Fig. 4, palm oil's energy output to input ratio is the highest at 9.6 compared to rapeseed and soybean, which only has ratio of 3.0 and 2.5, respectively. In this context, the contribution factor for energy input include energy to produce fertilizer, pesticides, fuel for machinery, sunlight and others which are essential to produce one unit of output energy. In palm oil mill, there is little or no fossil fuel required as palm biomass and shell are used as the source of energy during the processing of fruits into palm oil. Besides, palm oil's requirement for pesticides and fertilizers is also the lowest among the major vegetable oils [17]. Consequently, palm oil has a very efficient energy balance and is able to generate 9.6 units of energy for every single unit of energy consumed, which is important as it leads to reduced pollutant emissions and subsequently preserve water, soil and air quality [16].

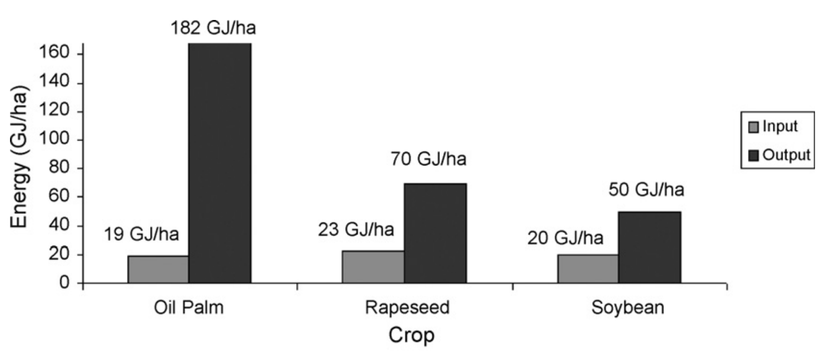
Apart from that, there is a general misperception that oil palm plantation, due to they being monocultures, are devoid of flora and fauna and affected the ecological stability. However, surveys conducted by Koh and Gan [18] and Golden Hope Plantations Bhd [19] indicated otherwise. In their surveys, biodiversity of flora and fauna in oil palm plantations are not affected but in fact a very high population of birds, butterflies and mammals are recorded. Even relatively rare species like leopard cat *Felis bengalensis* could be observed. This shows that oil palm plantation is able to maintain biodiversity and preserve the flora and fauna and not as bad as portrayed by some environmentalists.

All these statistics and reports conclude that reduced biodiversity and ecology instability of flora and fauna is not an issue in Malaysia's oil palm plantation as claimed by several NGOs. If deforestation and biodiversity loss are based on total forests available in a country, practically palm oil in Malaysia can be considered to be environmental friendly.

4. Towards sustainable development of palm oil

Sustainability of palm oil is crucial if this versatile crop is to become the leading vegetable oil in this world. This multipurpose vegetable oil needs to be cultivated in a proper manner to ensure sustainable development in terms of economic, social and environment. With so much dispute related to palm oil, policies and strategies need to be drafted in order to solve these matters. Nevertheless, the expansion of oil palm plantation is inevitable due to high demand of palm oil as the source of fats and oils. With the world's population is expected to increase to 8 billions in 2028 from 6.5 billions in 2005, only palm oil has the potential to be the source of fats and vegetable oil to feed the people around the globe [15]. Hence, it is not surprising if the world's top importers of CPO are India and China, both having billions of people in their countries. Apart from that, palm oil's potential to become the source of biodiesel also increases its market value. Nevertheless, palm oil's versatile applications, ranging from food products to biodiesel, have made it the most sought after vegetable oil in the world.

As high demand of cheap and quality vegetable oil is needed to feed the world's growing population and the urge to find renewable energy to replace non-renewable fossil foils is



Output/Input Ratio (O/I)	Oil Palm	Repeseed	Soybean
GJ/ha	9.6	3.0	2.5

Fig. 4. Comparison of energy ratio of output to input for palm oil, rapeseed and soybean [16].

unavoidable, a better management of palm oil production needs to be implemented in order to achieve sustainable development. In this context, all parties involved with palm oil like plantation owners, financial institutions and banks, manufacturers of palm oil products and governments should play an active role to realize this win-win situation for all.

Hence, the time has come for all parties to co-operate and realized a sustainable production and development of palm oil. Ideas and efforts will become futile if all parties do not take an active and responsible role towards this aim as sustainable development of palm oil required collaboration and initiative among the parties.

4.1. The roundtable on sustainable palm oil (RSPO) criteria

The roundtable on sustainable palm oil (RSPO) was formally established in 2004 to promote the growth and use of sustainable palm oil through co-operation within the supply chain and open dialogue between its stakeholders. This timely formation of RSPO is the first non-profit organization that aims to produce sustainable palm oil worldwide. Members of the RSPO and participants in its activities include plantation companies, manufacturers of palm oil products, environmental NGOs and social NGOs. RSPO define sustainable palm oil production as a legal, economically viable, environmentally appropriate and socially beneficial management and operations. This is realized through a policy know as RSPO Principles and Criteria which is applicable to the management of oil palm plantations and palm oil mills [20].

In this RSPO Principles and Criteria, there are eight principles which must be complied by palm oil companies in order to be certified as sustainable palm oil producer where their products certified by RSPO through RSPO Certification System [21]. One of them is transparency of management as stated in Principle 1. Oil palm growers and millers must provide adequate information to other stakeholders regarding environmental, social and legal issues related to the company. This act will help to counter the problem of companies not adhering to the rules and regulations especially in environmental issues. Transparency will also help NGOs to understand more about the management and operation of a palm oil company. Apart from that, a check and balance scenario will also take place where the NGOs could voice out any wrongdoings by the companies. Subsequently, Principle 2 of the Criteria stresses the importance of palm oil companies to comply the local and international laws and regulations. This is to ensure that palm oil companies do respect the local communities' ownership over their motherland and hence solve the conflicts that usually arise between these two parties.

Principle 3 stated that companies must be committed to long-term economic and financial viability. Palm oil companies must have management planning to ensure long-term economic and financial goals are achievable which are important to gauge their commitment towards palm oil industries. This will prevent some companies who clear forests and lands just for the timber, without developing it into oil palm plantation. Besides, palm oil growers and millers shall apply the best-known method (BKM) in their operations to maintain soil fertility, water quality and minimize the usage of agrochemicals. This is the main element in Principle 4 of the RSPO Criteria where the whole operating procedures are documented, implemented and monitored.

In Principle 5, companies must be responsible in conservation of natural resources and biodiversity. This is done by identifying any negative impacts of plantation on natural habitats and endangered species and subsequently taken into account in management plans and operations. Efficiency of energy use especially from renewable sources shall be maximized while reducing, recycling, reusing and disposing the wastes in an environmental and socially responsible manner. Principle 6 emphasizes the responsibilities of companies towards their employees and communities affected by oil palm plantations and palm oil mills. Negotiations regarding compensation for the land usage of indigenous communities must be dealt in transparent and open methods that enable the local communities to express their views and opinions. Besides, workers must be paid with industry's minimum standards which are sufficient to meet the basic needs of individuals. With these approaches, discrimination of workers and indigenous people by palm oil companies through land abuse and low salary can be solved.

Apart from that, opening of new plantations must be carried out in a sustainable manner. Social and environmental impact assessment must be undertaken before new plantings are established. Besides, opening of new area in virgin forests are strictly prohibited and the usage of fire to clear the land must be avoided. All these are the main elements in Principle 7 of the RSPO Criteria. To summarize everything in these Criteria, Principle 8 stresses the importance of companies' commitment towards continuous improvement in key areas of activity. This is done by monitoring and reviewing the current management and operation to ensure production of palm oil is in sustainable manner.

Malaysia has always been active members of RSPO with government agencies and private companies like Malaysian Palm Oil Association (MPOA), Federal Land Development Authority (FELDA), Golden Hope Plantation Bhd and United Plantation Bhd taking important roles and positions in RSPO organization. In fact, MPOA and Golden Hope were the founding members of RSPO in 2004 and this shows Malaysia's palm oil industries' commitment towards sustainable palm oil production and development. Furthermore, MPOA and FELDA are the current Executive Board members of RSPO, which manage RSPO activities. Currently there are 152 ordinary members of RSPO comprising oil palm growers, palm oil processors and traders, consumer goods manufacturers, retailers, banks and investors, environment NGOs and social NGOs. With huge support from those in palm oil industries, RSPO Principle and Criteria can be realized and subsequently march towards sustainable palm oil production.

4.2. Best management practice (BMP)

Apart from the Criteria from RSPO, palm oil companies must also have commitment and initiative towards sustainable

production of palm oil through environmentally responsible manner. The operation of the companies, from harvesting to producing palm oil related products, must be carried out with the best approach or BMP. These practices are environment-friendly approaches like zero burning, conservation of wildlife and habitat, Integrated Pest Management (IPM) and waste minimization and utilization. For instance, zero burning approach to clear land is taken in BMP to ensure that land clearing activities will not pollute the environment, particularly the air and water system. In BMP, rather than using agrochemicals like pesticides or herbicides for pests control and plant protection, IPM or Integrated Pest Management is apply to curb this problem. For example, barn owls are used to control rat populations in oil palm plantations rather than using pesticides, which are harmful to environment and the plant itself [22].

There are also other practices in BMP which contribute towards sustainable development of palm oil industries like planting of leguminous crops as a cover to mitigate and minimize soil erosion. This will ensure that soil fertility is maintained while soil erosion particularly at steep terrain will be prevented. For wastes like palm oil's empty fruit bunches (EFB), it is returned to the land as fertilizer for the nutrients. This will minimize the usage of inorganic fertilizers in oil palm plantations which are not environmental friendly. Apart from that, the fibre from EFB after separation processes can be utilized in pulp and paper industries to produce papers. This method to reuse wastes from palm oil mills is an important breakthrough for waste management in order to minimize the wastes generated by palm oil companies [15].

All these practices in BMP have been implemented and carried out extensively in Malaysia's oil palm plantation. Hence, it will ensure that palm oil companies, particularly in Malaysia are operating at maximum capacity while contributing to the conservation of environment. This win-win situation will allow palm oil industries to prosper and subsequently become the leading source of vegetable oil in the world.

5. Conclusion

Palm oil has been shown to be the most suitable candidate among all vegetable oils as the source of biodiesel production. High yield and low production cost are two of the major factors that made this vegetable oil attractive in terms of economic and environment. However, issues concerning this crop are damaging its' image as an environmental friendly vegetable oil. Some NGOs are lobbying to boycott palm oil products, which were produced from unsustainable oil palm production. Nevertheless, this paper has revealed the real facts behind palm oil production, which are in contrast to some NGOs claims. Besides, it is obvious that there is a need to introduce policies/strategies that will guide palm oil producers towards sustainable production and development. Hence, all parties involved with palm oil, from growers to consumer product manufacturers, should work closely to ensure that sustainable production is to be realized. Consequently, palm oil can become the major source of biodiesel in the world, replacing petroleum-derived diesel.

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